

# High-strain-rate shear testing applied to titanium

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## I. INTRODUCTION

In this contribution, two experimental techniques to study the dynamic shear behaviour of metals are presented and applied to Ti-6Al-4V. For bulk materials hat-shaped specimens are subjected to a high-strain-rate load in a split Hopkinson *compression* bar set-up. For sheet materials a purpose-developed, novel shear specimen geometry, is loaded in a Hopkinson *tensile* bar set-up. The value of both techniques to assess the dynamic material behaviour is discussed. Digital image correlation is used to extract the specimen deformation from high speed camera recordings. It is shown that the dynamic behaviour, including fracture of Ti-6Al-4V differs considerably from the static behaviour.

## II. EXPERIMENTAL TECHNIQUES

### A. Bulk materials

For testing bulk metals, the hat-shaped specimen [1] can be used. In this axis-symmetric specimen, shear strains are concentrated in a narrow zone. Figure 1 shows the specimen between the two Hopkinson bars. The region with high shear strains is marked with arrows.

The main advantages of the hat-shaped specimen are that materials are forced to shearing failure and that the deformation is concentrated in a very narrow region which means that very high shear strain-rates are automatically obtained. The technique is thus very suited to study the formation of localized

shear bands. In addition, the experiment can easily be interrupted by use of the stopper ring so that it is possible to study the shear band and the fracture at different levels of deformation.

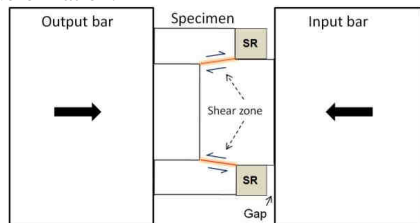


Figure 1: hat-shaped specimen

The disadvantages of the hat-shaped specimen are found in the complex, specimen dimension dependent stress state in the shear region and the impossibility to observe the shear region during the experiment because of its subsurface location.

Results of this experimental technique are presented on the accompanying poster.

### B. Sheet materials

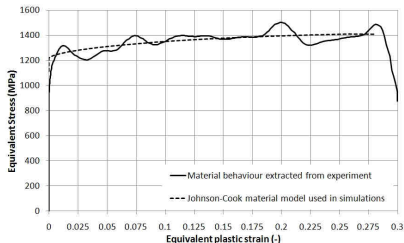
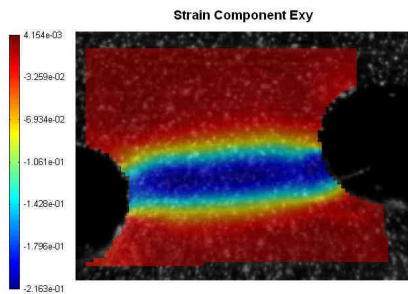
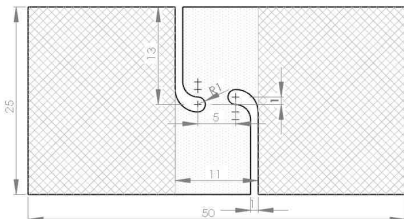
For sheet material testing, a novel sheet shear specimen geometry has been developed using finite element simulations. The specimen is optimised to be appropriate for dynamic testing and to have a pure-shear stress state in the shear region (triaxiality=0). The shear specimen is shown in figure 2.

The novel feature of this geometry is found in the eccentric position of the notches of the shear region. The centres of the notches do not coincide with the central axis of the specimen. The eccentric location of the notches lowers the stress triaxiality in the shear region (triaxiality=0 is pure shear). The

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The specimen does not require a special clamping system, but is instead glued onto the loading bars. In this way, sources of error due to inertia of the clamps, early rupture and buckling at the borders of the shear region and deformation under the clamps are avoided.



- [1] Peirs J, Verleysen P, Degrieck J, Coghe F. *The use of hat-shaped specimens to study the high strain rate shear behaviour of Ti-6Al-4V*. International Journal of Impact Engineering In Press, Corrected Proof